Goddard Procedural Requirements (GPR)

DIRECTIVE NO.	GPR 8710.7B	**APPROVED BY Signature:**	*Original Signed By*
EFFECTIVE DATE:	March 1, 2013	**NAME:**	Eric Isaac
EXPIRATION DATE:	March 1, 2020	**TITLE:**	Director, Safety and Mission Assurance

COMPLIANCE IS MANDATORY

Responsible Office: Code 360 / Safety Division

Title: Cryogenic Safety

PREFACE

P.1 PURPOSE

This directive establishes requirements for minimizing cryogenic hazards to personnel, hardware, and facilities at the Goddard Space Flight Center (GSFC). It also describes the controls and measures implemented by GSFC to assess and mitigate the hazards associated with cryogenic systems, such as over-pressurization, frostbite, and potential oxygen-deficient areas.

P.2 APPLICABILITY

a. This directive shall apply to all GSFC personnel, facilities, and activities at all permanent and temporary sites. This directive shall also apply to all GSFC tenant organizations, contractors, commercial operations, grantees, clubs, and other persons operating on GSFC property as required by law and as directed by contractual, grant, and agreement documents.
b. In this directive, all document citations are assumed to be the latest version unless otherwise noted.
c. In this directive, all mandatory actions (i.e., requirements) are denoted by statements containing the term "shall." The terms "may" or "can" denote discretionary privilege or permission; "should" denotes a good practice and is recommended but not required; "will" denotes expected outcome; and "are/is" denotes descriptive material.

P.3 AUTHORITIES

a. National Aeronautics and Space Act, 51 U.S.C. § 20113(a).

P.4 APPLICABLE DOCUMENTS AND FORMS

a. NPD 8710.5, Policy for Pressure Vessels and Pressurized Systems
b. NPR 8715.3, NASA General Safety Program Requirements
c. NPR 1441.1, NASA Records Retention Schedules
d. GPR 3410.2, Employee Task-Specific, Required and Mandatory Training Requirements
e. GPR 8621.4, GSFC Mishap Preparedness and Contingency Plan
f. GPR 8710.3, Certification and Recertification of Ground-Based Pressure Vessels and Pressurized Systems

g. GPR-8730.1, Calibration and Metrology
h. NASA-STD-8719.17, NASA Requirements for Ground-Based Pressure Vessels and Pressurized Systems (PV/S**)**
i. ANSI Z87.1: Occupational Eye and Face Protection
j. ASTM G63: Standard Guide for Evaluating Nonmetallic Materials for Oxygen Service
k. ASTM G88: Standard Guide for Designing Systems for Oxygen Service
l. ASTM G93: Standard Practices for Cleaning Methods and Cleanliness Levels for Material and Equipment used in Oxygen Enriched Environments
l. ASTM G94, Standard Guide for Evaluating Metals for Oxygen Service
m. ASTM MNL36, Safe Use of Oxygen and Oxygen Systems: Handbook for Design, Operation, and Maintenance
n. CGA Pamphlet G-4.1, Cleaning Equipment for Oxygen Service
o. CGA Pamphlet P-1, Safe handling of Compressed Gases in Containers
p. NFPA 50 Standard for Bulk Oxygen Systems at Consumer Sites
q. NFPA 55, Standard for the Storage, Use and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders and Tanks
r. OSHA 29 CFR 1910.104, Oxygen, Bulk Oxygen Systems, Distance between Systems and Exposures, Fire Resistive Structures
s. GSFC 23-81, Cryogenic Systems Hazards Analysis Checklist
t. GSFC 23-82, Dewar Personnel Certification
u. IEST-STD-CC1246, Product Cleanliness Levels and Contamination Control Program

P.5 CANCELLATION

GPR 8710.7A, Cryogenic Safety

P.6 SAFETY

None

P.7 TRAINING

Training for cryogenic personnel is covered in Section 5.0.

P.8 RECORDS

Documentation of training and certification is the responsibility of the appropriate management organization. See GPR 3410.2.

Record Title	Record Custodian	Retention
Liquid Nitrogen filling station user Certifications	Responsible Branch Head	*NRRS 3/33C Destroy 5 years after separation of employee or when no longer needed.

Record of Cryogenic Safety Committee (CSC) Minutes and Attendance	CSC Chair	*NRRS 1/14B1(a) Permanent. Retire to FRC when 2 years old. Transfer to National Archive and Records Management (NARA) when 20 years old.
CSC Cryogenic Safety Audit Records	Cryogenic Safety Engineer (CSE)	*NRRS 1/14B1(b) Destroy when 3 years old or when no longer needed for reference, whichever is sooner.
Liquid Oxygen Personnel Certification Record	Responsible Branch Head	*NRRS 3/33C
GSFC 23-81 Cryogenic Systems Hazards Analysis Checklists	Project Supervisor	*NRRS 1/14B1(b)
GSFC 23-82 Dewar Personnel Training Records	Project Supervisor	*NRRS 3/33C
Oxygen Deficient Atmosphere Training	Office of Human Capital Management (OHCM)	*NRRS 3/33C
Basic Cryogenic Hazards	OHCM	*NRRS 3/33C
Cryogenic Design, Operation, and Construction Training	OHCM	*NRRS 3/33C
On the Job Training	Supervisor	*NRRS 3/33C
System/Equipment Maintenance Records	Project Supervisor	*NRRS 1/14B1(b)
Monthly Inspection Records	Project Supervisor	*NRRS 1/14B1(b)
Inspection Records	System Owner	*NRRS 1/14B1(b)
Oxygen Sensor Calibration Records	Equipment Owner	*NRRS 1/124. Transfer to Federal Records Center (FRC) when 3 years old. Destroy 10 years after transfer.

**NRRS – NASA Records Retention Schedules (NRRS 1441.1)*

P.9 MEASUREMENT/VERIFICATION

a. Results of annual/periodic system reviews

PROCEDURES

1.0 Roles and Responsibilities

1.1 Goddard Safety Committee (GSC) shall oversee overall direction of GSFC's Health and Safety Program, including the Cryogenic Safety Program.

1.2 Chief, Safety Division shall:

a. Designate the Chair of the Cryogenic Safety Committee (CSC);
b. Provide notification to the Agency Occupational Health Officer (OHO) regarding any cryogenic or low oxygen atmosphere injury or incident; and
c. Appoint and maintain the position of CSE.

1.3 Branch Heads/Supervisors shall:

a. Designate custodians of cryogenic systems and Oxygen Deficiency Hazard (ODH)-designated areas;
b. Maintain a record of individuals trained on any cryogenic system;
c. Identify persons capable of providing the On the Job Training(OJT) specified in this document and, upon request of the CSC or CSE, provide justification that said persons are qualified to administer this training;
d. Ensure that all facilities and equipment are properly maintained;
e. Ensure that applicable employees are trained and knowledgeable in the hazards associated with cryogenic systems and potential oxygen deficiency;
f. Ensure that cryogenic safety requirements are in place on dewars used by their organization;
g. Ensure potential ODH areas are analyzed and classified according to Safety Division requirements and procedures;
h. Ensure that hazard warning signs required by this directive are procured and posted by the user organization under the guidance of the CSE; and
i. Ensure that oxygen monitors within their jurisdiction are maintained and calibrated as defined in GPR 8730.1.

1.4 CSC – The CSC will consist of representatives identified by their directorates as having appropriate areas of expertise. The CSC is responsible to the GSC and shall:

a. Oversee implementation and maintenance of GSFC's Cryogenic Safety Program, part of which is the ODH program;
b. Meet quarterly, or more frequently if necessary, to accomplish its responsibilities;
c. Ensure that the cryogenic safety program at GSFC minimizes the health and safety risks to government and contractor employees and the public as well as any risks to NASA hardware and facilities;

d. Halt any cryogenic operation if the requirements of this GPR are not met if unsafe practices are observed, or if equipment shows unexpected or anomalous performance.
e. Ensure that GSFC and other Federal regulations, professional standards, and sound health physics practices are met;
f. Review and approve new or altered cryogenic systems prior to their first operation for adherence to the requirements described in section 3.1 and, if necessary, prescribe conditions and requirements to minimize cryogenic hazards. The CSC may designate a person or persons to give approval for routine requests;
h. Review all cryogenic areas prior to startup of operations and after each approved alteration;
i. Specify posting and entry requirements for entry into designated ODH areas;
j. Develop and maintain the cryogenic working group charter; and
k. Review the inventory of all cryogenic systems and ODH designated areas at GSFC.

1.5 The Chair of the CSC shall:

a. Convene the CSC as necessary to meet the requirements of this GPR;
b. Maintain a record of CSC attendance and meeting minutes; and
c. Act on behalf of the CSC, as necessary.

1.6 The CSE shall:

a. Audit cryogenic safety records and evaluate compliance with CSC requirements;
b. Maintain appropriate records of inspections and evaluations;
c. Act on behalf of the CSC as necessary. All actions shall be reported to the CSC at the next meeting;
d. Require the immediate cessation of operations of any cryogenic systems or ODH area determined to pose an imminent threat to personnel safety;
e. Conduct periodic inspections of cryogenic or ODH areas for compliance to this GPR and to Industry standards for cryogenic safety; and
f. Develop and maintain an inventory of all cryogenic systems and ODH designated areas at GSFC

1.7 Users/Custodians – Users work directly with cryogens or cryogenic systems. Custodians are users who have primary responsibility for a cryogenic system:

a. All users of cryogens shall take the required cryogenic training described in this document and follow the directives and instructions described herein;
b. Custodians shall ensure that cryogenic safety hazards are reduced to as low a level as is reasonably achievable. This includes scheduling a safety analysis and review of their systems prior to first operation as described herein;
c. Custodians shall ensure alterations to any previously reviewed system which could possibly impact worker safety are reviewed by the CSC ; and

d. Custodians shall ensure that all safety documentation is updated and consistent with the operating system it is associated with, and be prepared to demonstrate this to the CSC, or CSE upon request.

1.8 Ancillary Personnel – Ancillary personnel work in the immediate vicinity of cryogens or cryogenic systems but do not work directly with them. They may also be personnel required to enter ODH designated areas as part of their normal work duties. Examples are security or custodial workers. Ancillary personnel shall take the required ODH and/or cryogenic training described in this document and follow the directives and instructions therein.

1.9 Contractor and Guest Cryogenic Operators – Contractors and other personnel operating at GSFC facilities are subject to all provisions of the GSFC Cryogenic Safety Program. Contractors may be exempt from GSFC specific training requirements if their cryogenic training program is reviewed and approved by the CSC. All contractor exemptions shall be coordinated and approved by the Contracting Officer responsible for a specific contract.

2.0 Requirements for Fabricated, Purchased, or Loaned Cryogenic Equipment

BRANCH/SUPERVISOR RESPONSIBLE FOR ENSURING ITEMS BELOW ARE CORRECT.

2.1 Commercial Off the Shelf (COTS) Products

COTS items shall be clearly designated for use at cryogenic temperatures. These items shall be used in strict accordance with manufacturer's specifications and operated as described in this GPR. Any modification to a COTS item is subject to review by the CSC as described herein. If a COTS product meets pressure vessel criteria as per NPD 8710.5, GPR 8710.3, or NASA-STD-8719.17 it shall be tracked as per Goddard Pressure Vessel System (PVS) requirements.

2.2 Custom Fabricated Equipment

Custom fabricated equipment which will operate at cryogenic temperature shall be designed and constructed in accordance with good cryogenic safety practices and made as safe as practicably possible. Pressure vessels shall conform to PVS requirements documented in NPD 8710.5, GPR 8710.3, and NASA-STD-8719.17. All specifications for custom fabricated equipment shall be reviewed by the CSE (or designee), and all operating cryogenic systems shall be reviewed by the CSC as set forth in this document. The responsible experimenter is required to supply any applicable safety documentation described in the CSC review section (3.1).

2.3 Legacy Systems

"Operating legacy cryogenic systems shall meet all applicable cryogenic safety requirements that were in place at the time of system manufacture. If changes to the system's critical components are beyond a like for like change then the system must be reviewed by the CSC."

2.4 Loaned Cryogenic Equipment

When equipment is on loan from another branch/organization, the safety responsibility lies in the branch/organization using the borrowed equipment. This includes ensuring that a safety peer review process (see Section 3.0) is done if any substantial changes are made to the initial system safety documentation. The branch/organization lending the equipment is obligated to provide any necessary instruction and documentation to support safe operation of that equipment. This includes but is not necessarily limited to: equipment documentation, operating procedures, maintenance requirements, and OJT.

3.0 CSC System/Equipment Reviews

To verify compliance with GSFC cryogenic safety requirements, cryogenic equipment and systems shall be:

a. Subjected to a safety review by the CSC prior to their first operation and
b. Prohibited from operating without formal approval from the CSC.

Any documentation listed in this section as required for CSC review will be supplied by the owner or operator of the system/equipment.

Systems that utilize commercial cryo-pumps in which the cold head has its own overpressure protection when physically isolated from the inside of the vacuum chamber are exempt from this requirement.

3.1 CSC Review Documentation

At least 2 weeks prior to first operation of any cryogenic system, the following applicable documents shall be supplied to the CSC as part of the system/equipment review process:

a. Schematics and piping and instrumentation flow diagrams as required providing a complete and accurate functional description of the system;
b. Sufficient documentation to show that the components and materials used are appropriate for cryogenic temperatures;
c. A description of operating procedures;
d. A description of any necessary operator training;
e. A list of all valves and ports which have the potential of discharging cold gas or cryogens to the atmosphere (the possibility of such a discharge causing personnel injury should be evaluated);
f. A description of any maintenance requirements;
g. An analysis demonstrating the adequacy of pressure relief valve sizing under worst-case failure conditions; and
h. A completed ODH analysis evaluating the risk presented under worst-case failure conditions. See Section 8.1.

The CSC may request additional documentation unique or specific to any cryogenic system under review.

3.2 CSC Review Process

The chair of the CSC shall:

a. Convene the group including the Pressure Systems Manager and meet with the responsible system operator after reviewing the safety documentation package.
b. Conduct a walkthrough of the cryogenic test setup prior to operations to ensure safety requirements are met
c. Review all ODH 1 areas upon initial designation to assist the owner of the space in defining mitigation strategies to reduce the overall hazard in the space.

The owner/operator of the system shall:

a. Complete a hazard analysis checklist, form GSFC 23-81, for review by the CSC prior to system operation.
b. Notify the CSC of any operating system configuration change that significantly alters the safety documentation for review and approval.

Code 360 shall perform periodic safety audits, occurring no less than annually, of operating cryogenic systems to ensure that safety documentation is consistent with the operating system with which it is associated.

4.0 Personal Protective Equipment (PPE)

Appropriate PPE is required when handling, transferring, or working with cryogenic fluids. If personnel are within an established exclusion zone, as determined by Project or Occupational Safety, PPE is required regardless of activity. PPE should be selected based on the specific cryogenic material to be used to prevent material compatibility issues. PPE shall include:

a. Eye protection – Safety goggles are required when handling or transferring fluids which might result in exposure to cold boil off gases such as an open system. Full face shield is recommended. Safety glasses with side shields are acceptable when working with closed cryogenic systems. Eye protection shall be in conformance with ANSI Z87.1;
b. Hand protection - Safety gloves rated for use with cryogenic fluids are required when working with cryogens.
c. Clothing -Non absorbent shirts and pants that minimize skin exposure are acceptable. Lab coats or aprons
are recommended; and
d. Footwear - Non absorbent footwear is required. Sandals or open-toed shoes are not permitted.

5.0 Training of Cryogenic Personnel

5.1 Training Requirements

All personnel working with cryogenic systems shall be thoroughly familiar with the hazards involved as defined in Table 1. They shall also be familiar with all emergency measures that may be required in the event of an accident. Any contractor organization that has an equivalent training program may be exempt from these training requirements with approval of the CSC.

Table 1. Training Requirements

	ODH	BASIC HAZARDS	DESIGN, CONSTRUCTION AND OPERATIONS	OJT
Entry into ODH Designated Areas	√			
Working with or around cryogens, basic use of Liquid Nitrogen (LN_2), or Liquid Argon (LAr), or Liquid Helium (LHe), or operation of a cryogenic system	√	√		√
Cryogenic system designers, liquid oxygen users, hands-on operators of sub-atmospheric LHe dewars	√	√	√	√
LN_2 Fill Station Responsible Trainers	√	√		√
Refresher Frequency	**3 years**	**3 years**	**3 years**	**As determined by System Owner**

5.2 Dewar User OJT Requirements

Prior to operation on any cryogenic systems, users shall be instructed in the following:

a. Description of the equipment;
b. Operating procedures including PPE requirements;
c. Maintenance schedule and procedures;
d. Hazards specific to a the particular test setup;
e. Location of ODH alarms and routes of egress in the event of an alarm; and
f. Procedures for reporting of incidents.

It is the responsibility of the branch/organization head to ensure that persons administering OJT are duly qualified. Requests for qualifications for OJT trainers may be made by the CSE or CSC. Form GSFC 23-82, Dewar Personnel Certification, may be used as a model for qualifying trainers. OJT group qualification is possible on a series of dewars if they are similar in hazards, design and operations.

On the Job Training shall be documented and records kept by the respective supervisor. The documentation shall include: 1) content of training, 2) date, 3) name of trainer, and 4) a dated training attendance list showing names of the trainees and their signatures. The CSE or CSC may request to review user qualification documentation for any operating cryogenic system.

5.3 User Certification for Liquid Nitrogen Filling Stations

All users of liquid nitrogen filling stations shall be certified on that particular station. The certification process shall require:

a. A review of the fill procedure, including any PPE requirements;
b. A description of the Dewar inspection process;
c. An explanation of the emergency procedures associated with cold contact burns and frostbite; and
d. A demonstration of the filling process by the user.

Users of liquid nitrogen filling stations need to be recertified if a modification is made to the filling station which affects its operation or potential hazards.

All stations shall have the name of responsible trainers and an operating procedure posted. It is the responsibility of the branch or organization owning the filling station to designate a responsible person and to maintain a record of certified users for each station. The responsible person for a LN_2 filling station shall be the primary certifier for new users at that station, and shall ensure that safety postings are maintained and an up to date operating procedure is available.

6.0 System Maintenance and Inspection

Qualified personnel shall:

a. Perform maintenance per equipment manufacturer or applicable NASA requirements;
b. Document the schedule and nature of the maintenance; and
c. Perform monthly inspections for unusual or excessive ice buildup, which can potentially block relief paths or may be a sign of a compromised insulating vacuum.

Cryogenic systems and equipment shall be inspected by the operator prior to and during system operations and after system shutdown. Inspection shall also take place after any incident which might affect the integrity and safety of an item of cryogenic equipment. Documentation of this maintenance shall be kept with the responsible organization.

7.0 Liquid Oxygen (LO_2) Safety

Because of the unique hazards associated with LO2 special precautions must be taken when designing and operating systems which utilizing LO2. System component design, configuration management, and selection of appropriate PPE are critical steps that should be thoroughly researched.

7.1 Applicable Standards

Because of the unique hazards associated with liquid oxygen, additional safety requirements are required to ensure safe operations.

7.1.1 Design Standards

LO_2 systems built, designed, or operated at Goddard shall conform to either: ASTM MNL36: Safe Use of Oxygen and Oxygen Systems: Handbook for Design, Operation and Maintenance or all applicable of the following:

a. ASTM G88: Standard Guide for Designing Systems for Oxygen Service;
b. ASTM G63: Standard Guide for Evaluating Nonmetallic Materials for Oxygen Service;
c. ASTM G94: Standard Guide for Evaluating Metals for Oxygen Service

7.1.2 Cleanliness Standards

LO_2 systems or components shall be cleaned in accordance with: ASTM G93: Standard Practices for Cleaning Methods and Cleanliness Levels for Material and Equipment Used in Oxygen Enriched Environments, Compressed Gas Association's (CGA's) Pamphlet G-4.1 : Cleaning Equipment for Oxygen Service, or IEST-STED-CC1245D Level 300B or better.

7.2 LO_2 Storage

7.2.1 Fixed or Permanent Storage - Fixed or permanent LO_2 storage requirements are determined by the amount of cryogen stored as defined below.

a. LO_2 storage less than the equivalent of 13,000 cubic feet shall be stored in accordance with NFPA 55: Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks
b. LO_2 storage greater than the equivalent of 13,000 cubic feet shall be stored in accordance with: 29 CFR 1910.104 (OSHA) Oxygen; Bulk Oxygen Systems; Distance between Systems and Exposures; Fire Resistive Structures
c. LO_2 storage greater than the equivalent of 25,000 cubic feet shall be stored in accordance with: NFPA 50 Standard for Bulk Oxygen Systems at Consumer Sites and OSHA 29 CFR 1910.104

Note: A typical 160 liter liquid oxygen dewar is approximately 5000 cubic feet.

7.2.2 Portable Liquid Oxygen or (LO_2) Dewar Storage

a. All portable oxygen dewars shall be separated from flammables and combustibles by a minimum of 20 feet. "No Smoking" and "No Open Flames" signs are to be posted at the storage location;
b. Smoking and open flame are prohibited within 20 feet of any oxygen Dewar or purge system; and
c. LO_2 dewar storage areas shall have fixed monitoring for high oxygen levels. These monitors shall alarm at 23.5% oxygen by volume.

7.3 User Certification for Liquid Oxygen Systems

All users of LO_2 shall be qualified. The list of OJT-required topics described in section 5.2 shall be expanded to include:

a. An explanation of oxygen material compatibility issues;
b. Combustion/flammability issues associated with LO_2 dewar storage areas;
c. A description of the hazards of high flow velocities in oxygen systems;
d. A description of the cleanliness requirements for oxygen systems;
e. Proper procedures for handling leaks and spills;
f. Recognition of normal operations and of symptoms that indicate deviations from such operations; and
g. Knowledge of the nature and properties of oxygen in both the liquid and gaseous phases.

Qualification records for liquid oxygen purchasers and users shall be kept by the responsible supervisor or branch head.

7.4 CSC Review Process for LO_2 Systems

Any system using liquid oxygen shall be reviewed by the CSC. For any LO_2 system review the following shall be added to the list of required safety documentation described in section 3.1:

a. Identification of designated Dewar or bulk LO_2 storage areas;
b. A plan for mitigation of combustion hazards;
c. Analysis of material compatibility with Oxygen (O_2);
d. Cleanliness procedures;
e. Analysis of piping design for minimization of flow velocities;
f. Electrostatic discharge risk mitigation plan; and
g. Procedures for implementing a buddy system when handling LO2 as required by the CSC.

8.0 Oxygen Deficiency Hazard

8.1 ODH Risk Assessment – An ODH assessment shall be conducted whenever an area containing enough displacing gas to pose a potential oxygen deficiency is established or modified, and wherever

cryogens are used, stored, or dispensed. The goal of the ODH risk assessment is to estimate the increase in the rate at which fatalities will occur in a given area so that appropriate controls can be established to mitigate the hazard. To have an ODH risk assessment completed contact the CSE or Code 360. The Safety Division shall designate the proper procedure for assessing the ODH hazard of a given area as well as the proper ODH alarm response procedure. Visit the Safety1st webpage for an example procedure. See Table 2 for the ODH classification definitions.

Personnel shall not enter or occupy an area where the oxygen level is less than 19.5% by volume.

8.2 ODH Signage. Areas determined to have a potential for oxygen deficiency shall be identified by signage, see appendix C. All entrances shall be posted. Persons authorized by the CSC or CSE can post and de-post areas if the hazard is temporary and an ODH analysis considering the change in potential displacing gas has been made. The ODH alarm response policy, as determined by the CSC, shall be posted adjacent to any fixed ODH alarm sensor or at the entrance to any ODH designated areas while the ODH threat is present.

8.3 Visitor Requirements. Visitors or temporary workers who have not had ODH training may enter a posted ODH area ONLY after the ODH hazard has been explained to them by personnel familiar with the hazards in the area and who have themselves taken the ODH training course. Visitors may not enter ODH 1 areas without taking ODH training and following all CSC requirements.

8.4 Oxygen Monitoring

8.4.1 Fixed Monitors. Fixed Oxygen monitors shall alarm at an oxygen concentration of 19.5% and have a siren and flashing strobe light. The siren and strobe shall be distinctive from other alarms in the immediate area, such as fire alarms. Oxygen monitors shall be installed with consideration of the buoyancy of the displacing gas. Fixed oxygen monitors shall not be disabled except by qualified personnel, in conjunction with the CSE.

8.4.2 Portable Oxygen Monitors. Portable oxygen monitors shall be readily accessible to ODH designated areas. Portable oxygen monitors will alarm at 19.5% oxygen. The organization issuing personal oxygen monitors is responsible for compliance with this requirement.

8.4.3 Maintenance and Calibration of Stationary and Portable Oxygen Monitors. Monitors shall be calibrated in accordance with GPR 8730.1 and manufacturer's recommendations. Monitors shall be verified at least annually using a known sample gas, which will verify the alarm set point of 19.5 %. Calibration records should be maintained by the organization that owns the equipment.

Table 2. ODH Requirements

ODH Classification	Description (Hours worked per fatality)	Door Posting Required	Portable O_2 Monitor	Fixed O_2 Monitor	Re-Entry Procedures Required
No Classification	>1 billion	No	N/A	N/A	N/A
ODH 0	>10 million	Yes	Recommended	Recommended	No
ODH 1	<10 million	Yes	Recommended	Required*	Yes

*If approved by the cryogenic safety engineer a portable oxygen monitor may be used in place of a fixed monitoring system.

Appendix A – Definitions

A.1 **Cryogenic** – Operating at or below -150 °C or 123° K.

A.2 **Cryogenic System** – An item of equipment or multiple items operating together that contain at least one component that operates at cryogenic temperature. Closed cycle refrigerators or cryo cooler setups are examples of cryogenic systems.

A.3 **Dewar** - A glass or metal container that may have an annular vacuum space for thermal isolation, which is used especially for storing components or gases at cryogenic temperature.

A.4 **Oxygen Deficient Atmosphere** – Occupational Safety and Health Administration (OSHA) defines an oxygen deficient atmosphere as one having less than 19.5% oxygen by volume

A.5 **Qualified Personnel** - Having sufficient knowledge, expertise and training required to complete a task, as deemed by the authority responsible for safe operations of the equipment with which that task is associated.

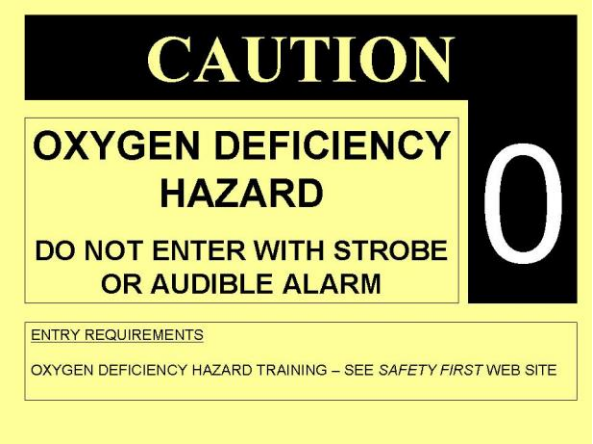
A.6 **Fixed Oxygen Monitoring System -** A system that has sensors affixed in a permanent manner such as in rigid conduit or mounted to a non-movable surface with a display device that does not have the ability to be freely moved while in service.

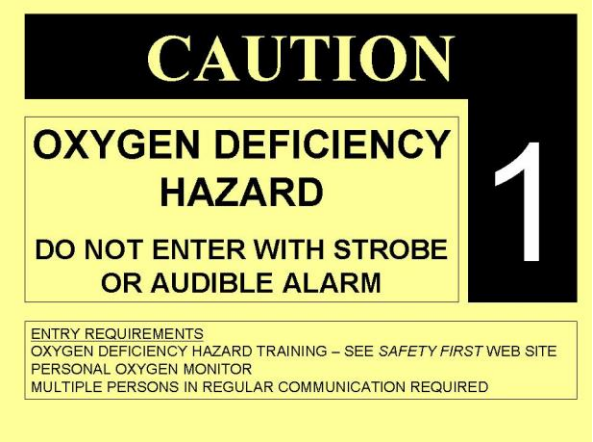
A.7 **Oxygen Deficiency Hazard –** Having the potential to displace enough air in a given space that the percent of oxygen would be less than 19.5% by volume.

Appendix B – Acronyms

ANSI	American National Standards Institute
ASTM	American Society for Testing
CGA	Compressed Gas Association
COTS	Commercial Off the Shelf
CSE	Cryogenic Safety Engineer
CSC	Cryogenic Safety Committee
FRC	Federal Records Center
GPR	Goddard Procedural Requirement
GSC	Goddard Safety Committee
GSFC	Goddard Space Flight Center
LAr	Liquid Argon
LHe	Liquid Helium
LN_2	Liquid Nitrogen
LO_2	Liquid Oxygen
NARA	National Archive and Records Administration
NASA	National Aeronautics and Space Administration
NFPA	National Fire Protection Association
NPD	NASA Policy Directive
NPR	NASA Procedural Requirement
NRRS	NASA Records Retention Schedule
O_2	Oxygen
ODH	Oxygen Deficiency Hazard
OHCM	Office of Human Capital Management
OHO	Occupational Health Officer
OJT	On the Job Training
OSHA	Occupational Safety and Health Administration
PV/S	Pressure Vessels and Pressurized Systems
PPE	Personal Protective Equipment
STD	Standard

Appendix C – ODH Signs





CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes
Baseline	03/04/08	Initial Release
A	11/10/10	Administratively revised to reflect new organization name and code change.
B	03/01/13	Document revised to reflect improved processes, clarify training requirements and meet internal mandates.
	02/12/18	Administratively changed to reflect new organization name and code and to update the GPR template. Administratively extend for 1 year.
	02/21/2019	Administratively extended for 6 months from current expiration date.
	08/29/2019	Administratively extended for 6 months from current expiration date.